Corporate social responsibility in portfolio selection: A "goal games" against nature approach

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A B S T R A C T

Nowadays, there is an uprising social pressure on big companies to incorporate into their decision-making process elements of the so-called social responsibility. Among the many implications of this fact, one relevant one is the need to include this new element in classic portfolio selection models. This paper meets this challenge by formulating a model that combines goal programming with "goal games" against nature in a scenario where the social responsibility is defined through the introduction of a battery of sustainability indicators amalgamated into a synthetic index. In this way, we have obtained an efficient model that only implies solving a small number of linear programming problems. The proposed approach has been tested and illustrated by using a case study related to the selection of securities in international markets.

1. Introduction

Markowitz (1952), more than sixty years ago, published an outstanding paper that established the foundations of modern finance theory in general, and of the portfolio selection problem in particular. His basic idea was to determine the investment opportunity set as a bi-criteria optimization problem that establishes the well-known mean–variance (E–V) frontier. Since then, Markowitz's seminal ideas have been preserved but, at the same time, they have been extended in many fertile directions. Kolm, Tütüncü, and Fabozzi (2014), is an updated analysis of how the Markowitz model has evolved throughout the last 60 years.

One improvement of the basic E–V model in this sense has consisted of the incorporation of additional criteria into the expected returns and their variance. This fertile line has connected the classic portfolio selection problem to the multiple criteria decision-making (MCDM) paradigm. A good state-of the art derived from this type of hybridization can be seen in Steuer and Na (2003). An assessment of this orientation from the point of view of decision system design can be seen in Zopounidis and Doumpos (2013). Finally, on these lines, when the MCDM tool used is specifically for goal programming (GP), some interesting operational results have been obtained (Aouni, Colapinto, & La Torre, 2014).

On the other hand, one important and relatively recent problem in business economics is the uprising social pressure on companies to incorporate into their decision-making processes elements of the so-called corporate social responsibility. It is obvious that these new elements must also be incorporated in one way or another into the portfolio selection problem. This considerably increases the complexity of the analysis since it requires the combination of financial, social and environmental criteria. Some authors (e.g., Bilbao-Terol, Arenas-Parra, and Cañal Fernández (2012, 2013)) have addressed this problem by making the portfolio selection among a set of companies that are considered *a priori* as being socially responsible. Afterwards, the performance of the portfolios obtained are compared with those derived from a selection process among a more general set of companies (i.e., those socially responsible or not). Another authors follow a slightly different orientation by undertaking the portfolio selection problem from conventional as well as from socially responsible mutual funds for comparative purposes (see Utz, Wimmer, Hirschberger, and Steuer (2014)).

In this paper, we have addressed the problem of the incorporation of corporate social responsibility by following a different orientation. Thus, we did not exclude companies due to their possible unethical economic activity (e.g., tobacco, gambling, etc) or we did not include companies for ethical reasons, but each company considered in the selection process has been assessed according to financial as well as environmental responsibility criteria. To undertake that task, a synthetic sustainability index was attached to each company considered. This index was obtained by aggregating different indicators measuring environmental and social sustainability aspects. The complexity attached to the combination of criteria of such a different nature requires the use of flexible analytical tools. We will explore this orientation with the help of a relatively new analytical approach known as "goal games" Against Nature. As a first step in our presentation the foregoing of this approach will be briefly described.

The inclusion of multiple pay-offs in game-theoretic models is a line of research with a long tradition (e.g., Bergstresser and Yu (1977), Corley (1985), Zeleny (1976)). However, most of this seminal research deals with the generalization of Nash equilibrium points for games with multiple pay-offs. A different research direction consists of incorporating the multiple pay-offs in "games-against-nature" models. In this way, the analytical structure known as "goal games-against nature" arises (Rehman & Romero, 2006). It is interesting to note that this approach is underpinned by a Simonian satisficing philosophy within an environment of bounded rationality (Simon, 1956; Simon, 1979). For those reasons, it seems interesting to explore the portfolio selection problem within a context of corporate social responsibility with the help of this type of goal games.

The paper is organized as follows. Section 2 is devoted to the presentation of the analytical structure of the proposed model. In Section 3 the main features of the case study chosen are described. Section 4 presents and discusses the results obtained. Finally, Section 5 shows the main conclusions derived from the research and highlights possible lines for future research.

2. The model

For a portfolio selection problem within a context of corporate social responsibility, the following criteria seem to be suitable:

(a) The maximization of the expected returns of the portfolio.
(b) The minimization of the variability of the returns of the portfolio. As a variability index the negative semi-variance of the returns was chosen.
(c) The minimization of the maximum "regret".
(d) The maximization of a sustainability index of the portfolio.

Criteria (a) and (b) are the traditional criteria for the Markowitzean models, but using here the negative semi-variance instead of the variance as was suggested by Markowitz (1970, pp. 188–201). The inclusion of the Savage criterion implies that the investor feels a dissatisfaction quantified by the difference between the return actually achieved and the maximum possible return. Hence, the investor wishes to minimize the maximum possible value of this regret or opportunity cost. Finally, the sustainability index was obtained by aggregating a battery of sustainability indicators for each of the companies considered in the analysis.

Consequently, in this section, we have built a model capable of dealing with a portfolio selection problem involving the above set of criteria. For this purpose, the following notations are used:

n = number of securities under consideration (1,...*i*,...,n).
m = number of periods of time or sates of nature analyzed (1,...*j*,...m)
x_i = fraction of the portfolio invested in the ith security.
R_{ij} = generic element of the matrix of outcomes; i.e., returns obtained by the ith security under period of time (state of nature) jth.
S_{ij} = generic element of the "Savage matrix"; i.e., the "regrets" obtained by calculating the differences between the returns actually achieved by the ith security and the maximum return for the jth state of nature.
E_i = expected return of the ith security. Obviously, we have:

$$E_i = \frac{1}{m}\sum_{j=1}^{m} R_{ij}$$

V_i = negative semi-variance for the returns of the ith security. This variability index will be equal to:

$$V_i = \frac{1}{m}\sum_{j=1}^{m}(R_{ij} - E_i)^2, being\, R_{ij} \le E_i$$

I_i = Sustainability index attached to the ith security. In the next section some guidelines on how to calculate this index will be provided.
W_S, S = preferential weight and "satisficing" target value, respectively, for the "Savage criterion".
W_E, E = preferential weight and "satisficing" target value, respectively, for the "expected return criterion".
W_V, V = preferential weight and "satisficing" target value, respectively, for the "negative semi-variance criterion".
W_I, I = preferential weight and "satisficing" target value, respectively, for the "sustainability criterion".

The basic structure of the "goal games" against nature is the following (see for technical details Rehman and Romero (2006)).

Goals:

$$\sum_{i=1}^{n} E_i x_i + n_E - p_E = E \tag{1}$$

$$\sum_{i=1}^{n} S_{ij} x_i + n_{Sj} - p_{Sj} = S \quad j \in \{1, \ldots, m\} \tag{2}$$

$$\sum_{i=1}^{n} V_i x_i + n_V - p_V = V \tag{3}$$

$$\sum_{i=1}^{n} I_i x_i + n_I - p_I = I \tag{4}$$

Constraints:

$$\sum_{i=1}^{n} x_i = 1 \tag{5}$$

$$x_{i\,\min} \le x_i \le x_{i\,\max} \quad i \in \{1, \ldots n\} \tag{6}$$

The above constraints guarantee that all the wealth will be invested as well as that there are possible upper and lower bounds for the fraction invested in each security as is usual in the financial practice.

Regarding the block of goals, it is of interest to note that the negative deviation variables n_E, n_{Sj}, n_V and n_I quantify the under-achievement with respect to the target values, while the positive deviation variables p_E, p_{Sj}, p_V and p_I quantify the opposite effect, that is, the over-achievement from the target values. Since the expected returns and the sustainability criteria derive from attributes of the type "more is better", then the unwanted deviation variables to be minimized will be the negative ones (i.e., n_E and n_I) and as the "regret" and the semi-variance criteria derive from attributes of the type "less is better", then the unwanted deviation variables to be minimized will be the positive ones (i.e., p_{Sj} and p_V). Consequently in order to obtain a "satisficing" portfolio, a certain function of these unwanted deviation variables has to be minimized as follows:

$$\mathrm{MIN} = F(n_E, \sum_{j=1}^{m} p_{Sj}, \mathrm{pv}, n_I) \tag{7}$$

Among the different possible achievement functions, we propose the following structure inspired by the idea of extended goal programming (Romero, 2001; Romero, 2004):

Achievement function:

$$\mathrm{MIN} = (1-\lambda)D + \lambda\left(m\frac{W_E}{E}n_E + \frac{W_S}{S}\sum_{j=1}^{m}p_{Sj} + m\frac{W_V}{V}p_V + \mu m\frac{W_I}{I}n_I\right)$$

Subject to:

$$m\frac{W_E}{E}n_E + \frac{W_S}{S}p_{Sj} + m\frac{W_V}{V}p_V + \mu m\frac{W_I}{I}n_I - D \leq 0 \quad j \in \{1,\ldots m\} \tag{8}$$

Goal and constraints (1)–(6)

In order to overcome incommensurability problems the unwanted deviation variables appearing in the achievement function of model (8) have been normalized by dividing each of them by their target values. This ensure that all deviations were measured on a percentage scale (see e.g., Tamiz, Jones, and Romero (1998, pp. 572–573), Jones and Tamiz (2010, pp. 34–39)).

The above achievement function combines the maximum aggregated achievement of the portfolio with its maximum balanced character. Thus, variable D measures the maximum deviation; that is, among the m periods of time or states of nature considered, the one for which the aggregate achievement of the goals considered achieves the worst value. λ is a control parameter playing a crucial role. Thus, when this parameter takes the value 1, then the first term of the above achievement function disappears and the solution provided by the model implies the portfolio that maximizes the average achievement for the criteria considered. On the contrary, when control parameter λ takes a value of 0, then the second term of the achievement function disappears and the solution provided by the model implies the portfolio with a most balanced achievement for the criteria considered. On the other hand, for values of control parameter λ belonging to the open interval $(0,1)$ possible compromise portfolios, if they exist, can be obtained. In other words, attaching to λ values belonging to the interval $(0,1)$, we can determine the existing compromises between "optimal average achievement" versus "optimal balanced achievement". Thus, the control parameter λ allowed us to quantify the trade-offs or marginal rates of substitution between average ("efficiency") and balance ("equity"). Finally, μ is an auxiliary binary parameter that takes the value 0, when the sustainability aspects are not considered and takes the value 1 when sustainability is competing with the other three criteria in the determination of the structure of the portfolio. Thus, with this simple devise, we were able to compare the possible changes of financial returns associated with the inclusion in the decision-making process of the corporate social responsibility trough the incorporation of sustainability aspects.

Finally, it should be noted any goal programming model can provide a solution that is not efficient in a Paretian sense (e.g., Tamiz and Jones (1996)). There are many procedures to check if the solution obtained is an efficient one and, in case of non-efficiency, to restore it (see Jones and Tamiz (2010, pp. 95–110)). For our model, the most straightforward approach to dealing with the Paretian efficiency problem is to solve the model again by maximizing the wanted deviation variables and keeping the values of the unwanted ones in the optimal values previously obtained. If the solution obtained does not change then the previous optimal solution is efficient. However, if the solution changes, then, this solution dominates in a Paretian sense the previous one. In our model, we should solve a GP model subject to the goals and constraints previously defined as well as guaranteeing the optimal values obtained for the unwanted deviation variables. The auxiliary GP model structure is the following:

Achievement function:

$$\begin{aligned}
&\mathrm{Max} = p_E + \sum_{j=1}^{m}n_{Sj} + n_V + p_I \\
&\text{Subject to}: \\
&\text{Goals and constraints of model}(8) \\
&n_E \leq n_E^*, \quad \sum_{j=1}^{m}p_{sj} \leq \sum_{j=1}^{m}p_{sj}^*, \quad p_V \leq p_V^*, \quad n_I \leq n_I^*
\end{aligned} \tag{9}$$

where the deviation variables with the superscript $*$ indicate the optimal values of these variables provided by model (8). The above procedure can be interpreted as a lexicographic goal programming (LGP) process. Thus, achievement functions of models (8) and (9) correspond to the first and the second component of the lexicographic vector, respectively. Then, the LGP problem is solved sequentially. If the first problem of the sequence has no alternative optimal solutions the process stops. Otherwise, the minimization of the second component is undertaken in order to obtain an efficient GP solution (see Romero (1991, pp. 13–21), for a mathematical justification of this procedure). This type of procedure will be implemented in all the exercises done in the next sections in order to guarantee the efficiency of all the portfolios obtained.

3. Description of the case study

In order to test the model presented in the preceding section, 20 companies were selected by following geographical as well as industrial diversification criteria. Table 1 shows the names and main features of the companies selected.

By resorting to the repository of data online of **Yahoo! Finance** (www.finance.yahoo.com) and **Google Finance** (www.google.com/finance) the fortnightly quotations of the 20 companies throughout the year 2012 were obtained. With this data, a game matrix of size 20 (number of companies) by 104 (number of periods of time) was straightforwardly obtained. From this matrix the Eqs. (1)–(3) corresponding to the three financial goals of the model can be fed.

In order to obtain the value of the synthetic sustainability index to be attached to each one of the 20 companies selected, a battery of indicators reflecting different aspects of the sustainability of each company were calculated. Table 2 gives the indicators used as well as a brief description of their main characteristics.

The above indicators were calculated for the 20 companies during the year 2012. In this way a matrix of size 20 (number of companies) by 6 (number of indicators) was obtained. Since the indicators are measured in different units, these data were normalized and after that were aggregated into a synthetic sustainability index. To undertake this task, the methodology proposed by Diaz-Balteiro and Romero (2004) was applied. In short, the following normalization procedure is used:

$$\overline{IN}_{ik} = 1 - \frac{IN_k^* - IN_{ik}}{IN_k^* - IN_{*k}} = \frac{IN_{ik} - IN_{*k}}{IN_k^* - IN_{*k}} \quad \forall i,k$$

where $\overline{IN}_{ik}$ is the normalized value of the sustainability index reached by the ith company when it is evaluated according to the kth sustainability indicator. It should be noted that IN_k^* is the optimal or ideal value for the kth sustainability indicator. This ideal value represents the maximum value if the indicator is of the type "more is better", or the minimum value if the indicator is of the type "less is better". In the same way, IN_{*k} is the worst value or anti-ideal value for the kth sustainability indicator; that is, the minimum value if the indicator is of the type "more is better" and the maximum value if the indicator is of the type "less is better". With this normalization system, the indicators do not have any dimension and they are all them bounded between 0 and 1; that is, from the worst to the best of the criteria values according to a local scale.

Table 1
List of companies selected for the case study.

Company	Sector	Country	Market capitalization (€m)
Bayer	Pharmaceutical	Germany	67,752
CaixaBank	Financial services	Spain	10,965
Cathay Pacific	Airline	China	5206
China Everbright	Financial services	China	2378
EDP	Utilities	Brazil	8984
Enel	Utilities	Italy	22,654
Fiat Industrial	Industrial	Italy	10,602
HK Exchanges	Financial services	China	102,052
Intel Corporation	Technology	US	91,259
Kia	Motor	Korea	16,599
Kimberly Clark	Household and personal	US	28,312
Lafarge	Real estate	France	13,570
Mirvac	Real estate	Australia	3857
Nestle	Food and beverages	Switzerland	161,116
Samsung	Technology	Korea	133,505
Shell	Natural resources	Netherlands	156,890
Swire Properties	Real estate	China	13,201
Telefónica	Telecommunications	Spain	44,805
UPS	Logistics	US	61,889
Vedanta	Mining	UK	3173

Source: Yahoo! Finance and Google Finance. Market capitalization and exchange rates as of 30th June 2013.

Table 2
List of indicators and their main characteristics.

	Indicator	Category	Units	Type
A	Greenhouse gas emissions	Environmental	('000 CO_2 tons equivalent)/(€m of net income)	"Less is better"
B	Water consumption	Environmental	('000 m^3)/€m of net income)	"Less is better"
C	Energy consumption	Environmental	(Giga Joules)/(€m of net income)	"Less is better"
D	Employee diversity	Social	Percentage of deviation (absolute) vs. gender equality 50/50%	"Less is better"
E	Employee training hours	Social	Yearly training hours per employee	"More is better"
F	Community investment	Social	€ community investment/€ of net income	"More is better"

Finally, the synthetic sustainability index associated with ith company will be equal to:

$$I_{\mathrm{i}} = \sum_{\forall k} \alpha_k \overline{IN_{ik}}$$

α_k being the preferential weight attached to the kth sustainability indicator (for technical details see again Diaz-Balteiro and Romero (2004)).

In Trenado (2013) the precise figures achieved for the different companies for each indicator, their normalized values as well as the sources from which the basic data were obtained can be seen. Table 3 displays the aggregate or synthetic sustainability index for the 20 companies selected, under different weights structure; that is, by implementing a sensitivity analysis with the preference weights or relative importance attached to each sustainability criterion. In the development of our exercise, we used the synthetic indicator values corresponding to the third solution shown in Table 3.

An upper bound of 0.06 for every security was established and we only need to fix the "satisficing" target values for the four goals considered in order to compute our basic model given by (8). The targets were fixed in the 90% of the ideal or anchor values achieved by each goal; that is, the maximum expected return and the maximum sustainability index, as well as the minimum "regret" and the minimum semi-variance subject to the constraints of the model (inequalities (5) and (6)). In this way, the pay-off matrix shown in Table 4 was obtained.

It should be noted that the three financial goals are measured in fortnightly percentages, while the sustainability goal represents the percentage of achievement with respect to the respective ideal value, that for construction is 1. Now we have all the necessary information to feed the model defined in the preceding section and to run it under different scenarios. The results obtained will be presented and discussed in the next section.

4. Results and discussion

The proposed model for the 20 securities chosen was computed under different scenarios. In this section, only some of the results obtained will be presented. A complete presentation of the results can be seen in Trenado (2013). In order to research the influence of the sustainability criterion in the performance of the optimal portfolio, model (8) was solved for two different values of the auxiliary binary parameter μ. Thus, making $\mu = 0$ in the model, the optimal "pure financial portfolio" was obtained, and, alternatively making $\mu = 1$ the optimal "social responsible portfolio" was elicited. In both cases, equal preferential weights are attached to the goals considered. That is, when the pure financial portfolio is sought we have:, $W_E = W_S = W_V$, and when the sustainable portfolio is researched, we have: $W_E = W_S = W_V = 1$, and $W_I = 3$. With this strategy, we are attaching the same weight to the financial aspects as to the sustainable aspects of the problem. We insist that the model was run for different weight vector values. These results can be seen in Trenado (2013).

Table 5 shows the results obtained for the "pure financial portfolio" (i.e., $\mu = 0$) for three different values of control parameter λ. The results are shown in the goal space, as well as in the decision variable space. Thus, for $\lambda = 1$, we obtained the best possible financial portfolio from the point of view of the average achievement, whereas for $\lambda = 0$ the portfolio with the most balanced achievement in the three goals considered is obtained. Finally, for $\lambda = 0.5$, something like a compromise portfolio between these

Table 3
Values of the synthetic sustainability index achieved by each company.

	Structure 1 Equal Weight	Structure 2 More importance to environmental criteria	Structure 3 More importance to gas emissions, water consumption, energy consumption and community investment
Structure of weights			
A (Gas Emissions)	1/6	2/9	5/18
B (Water Consumption)	1/6	2/9	1/18
C (Energy Consumption)	1/6	2/9	5/18
D (Diversity)	1/6	1/9	1/18
E (Training)	1/6	1/9	1/18
F (Community Investment)	1/6	1/9	5/18
Bayer	0.327	0.382	0.334
CaixaBank	0.486	0.491	0.495
CathayPac.	0.306	0.317	0.224
China EB.	0.135	0.145	0.157
EDP	0.276	0.326	0.307
Enel	0.313	0.375	0.334
Fiat Ind.	0.329	0.384	0.335
HK Exch.	0.336	0.390	0.334
Intel	0.308	0.372	0.327
Kia	0.276	0.351	0.315
Kimberly C.	0.322	0.378	0.331
Lafarge	0.310	0.362	0.333
Mirvac	0.321	0.381	0.330
Nestle	0.297	0.364	0.321
Samsung	0.403	0.435	0.361
Shell	0.321	0.379	0.327
Swire Prop.	0.316	0.377	0.329
Telefónica	0.375	0.416	0.357
UPS	0.297	0.363	0.321
Vedanta	0.190	0.220	0.153

two opposite solutions is elicited. It should be noted that Z measures the optimum value achieved by the second term of the achievement function; i.e., the maximum average achievement for the criteria considered.

Table 6 shows the results obtained when the sustainability goal is amalgamated with the three financial goals (i.e., $\mu = 1$). The results are presented again in the goal and in the decision variable spaces, for the same three values of control parameter λ. For comparative purposes, the percentage changes of the sustainable portfolio with respect to the financial one were calculated for the four goals considered and for the three values of control parameter λ .These results are shown in Table 7. In the last column of this table, the corresponding percentage increases and decreases are calculated. The plus sign indicates an improvement and the negative sign a worsening, respectively, in the performance of the four goals due to the inclusion of the corporate social responsibility.

From the results shown in Tables 5–7 some basic conclusions are obtained. Thus, the inclusion of the sustainability goal modifies the structure of the portfolios, as well as the achievement values of the different goals. However, for this particular case study, these changes are very slight. Thus, the inclusion of the sustainability

Table 5
Optimal financial portfolios in the goal and in the decision variables spaces.

λ	1	0.5	0
D	0.8074	0.7843	0.7099
Z	0.3686	0.3766	0.4863
Return (%)	0.84	0.84	0.84
Savage (%)	18.26	18.20	17.82
Semi-variance (%)	0.11	0.11	0.11
Bayer	6.00%	6.00%	6.00%
CaixaBank	–	–	0.71%
Cathay Pacific	6.00%	6.00%	6.00%
China Everbright	6.00%	6.00%	6.00%
EDP	6.00%	6.00%	2.15%
Enel	6.00%	6.00%	6.00%
Fiat Industrial	6.00%	6.00%	6.00%
HK Exchanges	6.00%	6.00%	6.00%
Intel	6.00%	6.00%	6.00%
Kia	4.18%	0.11%	1.20%
Kimberly Clark	–	–	–
Lafarge	6.00%	6.00%	6.00%
Mirvac	6.00%	6.00%	6.00%
Nestle	6.00%	6.00%	6.00%
Samsung	6.00%	6.00%	6.00%
Shell	6.00%	6.00%	6.00%
Swire Properties	6.00%	6.00%	6.00%
Telefónica	1.50%	6.00%	5.93%
UPS	6.00%	6.00%	6.00%
Vedanta	4.32%	3.89%	6.00%

Table 6
Optimal sustainable portfolio in the goal and in the decision variables spaces.

λ	1	0.5	0
D	1.0858	1.0314	1.0297
Z	0.8449	0.8789	0.8865
Return (%)	0.84	0.83	0.83
Savage (%)	18.34	17.97	17.93
Semi-variance (%)	0.12	0.12	0.12
Sustainability (%)	32.61	32.72	32.79
Bayer	6.00%	6.00%	6.00%
CaixaBank	6.00%	6.00%	6.00%
Cathay Pacific	6.00%	6.00%	6.00%
China Everbright	6.00%	4.84%	4.34%
EDP	2.90%	5.70%	6.00%
Enel	6.00%	6.00%	6.00%
Fiat Industrial	6.00%	6.00%	6.00%
HK Exchanges	6.00%	6.00%	6.00%
Intel	6.00%	5.46%	5.66%
Kia	–	–	–
Kimberly Clark	–	–	–
Lafarge	6.00%	6.00%	6.00%
Mirvac	6.00%	6.00%	6.00%
Nestle	6.00%	6.00%	6.00%
Samsung	6.00%	6.00%	6.00%
Shell	6.00%	6.00%	6.00%
Swire Properties	6.00%	6.00%	6.00%
Telefónica	1.10%	–	–
UPS	6.00%	6.00%	6.00%
Vedanta	6.00%	6.00%	6.00%

Table 4
Pay-off matrix for the four goals considered. Bold characters denote ideal values and underlined figures anti-ideal values.

	Return (%)	Savage (%)	Semi-variance (%)	Sustainability (%)
Return	**0.88**	18.05	0.12	<u>31.62</u>
Savage	<u>0.50</u>	**17.07**	0.16	34.24
Semi-variance	0.70	<u>19.55</u>	**0.10**	32.22
Sustainability	0.56	17.78	<u>0.20</u>	**34.43**

Table 7
Performance comparison of the financial and sustainable portfolios in the goal spaces.

	Financial portfolio (%) [A]	Sustainable portfolio (%) [B]	Variation (%) $[B/A - 1] \times 100$
Most efficient scenario ($\lambda = 1$)			
Return (%)	0.84	0.84	–
Semi-variance (%)	0.11	0.12	9.09 (–)
Savage (%)	18.26	18.34	0.44 (–)
Sustainability (%)	31.45	32.61	3.69 (+)
Compromise scenario ($\lambda = 0.5$)			
Return (%)	0.84	0.83	1.19 (–)
Semi-variance (%)	0.11	0.12	9.09 (–)
Savage (%)	18.20	17.97	1.26 (+)
Sustainability (%)	31.62	32.72	3.47 (+)
Most balanced scenario ($\lambda = 0$)			
Return (%)	0.84	0.83	1.19 (–)
Semi-variance (%)	0.11	0.12	9.09 (–)
Savage (%)	17.82	17.93	0.62 (–)
Sustainability (%)	31.86	32.79	2.92 (+)

goal has generated very little worsening in the achievement of the financial goals and a slight improvement in the achievement of the sustainability goal. These results do not conflict with recent research which find that there is no significant difference in how the securities are allocated between socially responsible and conventional financial mutual funds (Utz et al., 2014).

It is also interesting to note that these results are rather stable to changes in the value of control parameter λ. This result implies that for our exercise the portfolios optimizing the average achievement and the portfolios optimizing the balanced achievement are fairly similar. Finally, it should be noted that the improvement in the value achieved by the sustainability index varies from an increase of 3.69% for the "maximum average portfolio" to 2.92% to the "most balanced portfolio".

5. Conclusions and further research

The method proposed in this paper, underpinned by a "satisficing" logic seems promising, when the corporate social responsibility is incorporated among the different goals set by the companies. We are aware that we are dealing with a fairly new problem, and that there are other efficient methods proposed in the literature. However, the approach expounded in the paper might present some advantages, such as:

(a) Corporate social responsibility is not incorporated by an *a priori* exclusion or inclusion of companies for ethical reasons, which might be questionable. On the contrary, an objective index of sustainability is attached to each company. Thus, the trade-offs (opportunity costs) between financial and environmental performances can be quantified.
(b) All the criteria introduced into the model can be easily understood by the investor, which can make easier further interactions. Moreover, there are many accessible data sources with which to the feed the model.
(c) The computation burden is light since all the models imply the solution of linear programming problems of a moderate size. This is an important advantage with respect to Markowitzean approaches which require the computation of large non-linear models.
(d) In a clear way, the model provides different solutions for the investor in terms of "maximum average achievement, "maximum balanced achievement" or compromises between these two opposite solutions.
(e) The proposed method allows the quantification of possible financial losses due to the inclusion in the decision-making process of the corporate social responsibility.

This research can be extended by following different directions. Thus, for any particular investor we can resort to an interactive process in order to obtain reliable estimates of the values of the preferential weights as well as of the target values for the different goals. In this way, the portfolios obtained will reflect with more accuracy the real preferences of the investor. In short, with that strategy the model can be customized for specific investors. Incorporating the temporal variable into the model is a further challenge. In fact, the investment process is actually a dynamic one, in which the continuous review of the investorś preferences, sources of information, etc., are necessary.

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